Effect of Deodorization and Antioxidants on the Stability of Lard

R. W. RIEMENSCHNEIDER, S. F. HERB, E. M. HAMMAKER, and F. E. LUDDY
Eastern Regional Research Laboratory,[1] Philadelphia, Pennsylvania

MOST of the lard that enters commercial channels has had little or no processing. A small proportion may have been subjected to a mild refining consisting essentially of treatment with an adsorptive agent such as carbon or fuller's earth, followed by filtration. Lard has been considered a finished product. Although the nutritional and shortening properties of commercial lard are fully equal to those of other shortenings, it has certain disadvantages that some competitive shortenings do not have. It is comparatively low in stability, of variable consistency, and frequently has too low a melting point for storage at room temperature. The smoke point is occasionally too low for a desirable frying fat. Whether or not the odor and flavor of fresh lard are desirable, appears to be a matter of opinion. In view of the recent trend toward the use of bland vegetable shortenings, however, the possible market for bland lard should not be discounted.

Research in the past decade has shown that fats and oils owe their stability largely to inherent antioxidants. Probably the principal antioxidant, particularly in vegetable seed oils, is tocopherol. Lard does not contain sufficient amounts of tocopherol or other inherent antioxidants to provide adequate stability, although it is recognized that the stability could be increased by improvements in commercial rendering and handling. It appears therefore that the problem of increasing the stability of lard centers about the choice of a suitable antioxidant. Once the stability problem has been solved, other disadvantages can readily be overcome by refining, hydrogenation or addition of hydrogenated lard, and deodorization.

Considerable progress has been made in recent years in selecting suitable antioxidants. Various publications have dealt with the effect produced by gum guaiac (1, 2), tocopherol (3, 4, 5, 6, 7, 8), and nordihydroguaiaretic acid (9). Accelerated stability tests indicate that in general these antioxidants are much more effective in lard containing acidic synergists, such as ascorbic acid, esters of ascorbic acid, citric acid, tartaric acid, and commercial lecithin. As a result of research in this field to date, permission has been granted to add to lard and "rendered pork fat" small amounts of gum guaiac (10), lecithin (11), nordihydroguaiaretic acid (12), and a concentrate of tocopherols in vegetable oil (13), providing specific declaration is made on the label.

No published information is available concerning the effect on the stability of lard, of deodorization either when used alone or with antioxidants. Treatises on modern methods of deodorization (14) and modern theory and practice (15) have been published, and recently a deodorization apparatus suitable for laboratory use has been described (16).

Data obtained in this Laboratory on the effects of deodorization and the addition of tocopherol and nordihydroguaiaretic acid and combinations of these antioxidants with synergists form the basis of the present report. Deodorization was carried out both before as well as after the addition of the antioxidants. In some of the experiments stability values were determined both by the active oxygen method and by the oxygen absorption technique using the Barcroft-Warburg apparatus.

Experimental

THE apparatus used for the deodorization experiments was similar to that described by Bailey and Feuge (16), with certain modifications. As shown in Figure 1, the steam pot (A) was merely a 500-ml. flask surrounded by a water bath, which controlled the temperature in the pot and thus the steam input. The steam inlet tube was sealed into the deodorization flask (B) to prevent any possibility of a leak and consequent contact of air with the hot oil. The direct connection between the steam generator and the vacuum pump through stopcock 1 serves two purposes: (a) most of the air in the steam pot can be evacuated without drawing it through the oil in the flask (stopcock 1 must be closed, of course, before excessive moisture is drawn from the steam pot into the system, and it is kept closed during the run); and (b) releasing the vacuum at the conclusion of a distillation is greatly facilitated (by opening first stopcock 1 and then stopcock 2, there is no possibility of either drawing oil back into the generator or pulling any air through the oil).

In the deodorization experiments, 100 grams of lard was weighed into a 500 or 1000 ml. flask, and the flask was connected to the steam pot and the spray trap. The system was then evacuated and maintained at a pressure of from 2.0 to 2.5 mm. of mercury. After evacuation, the contents of the flask

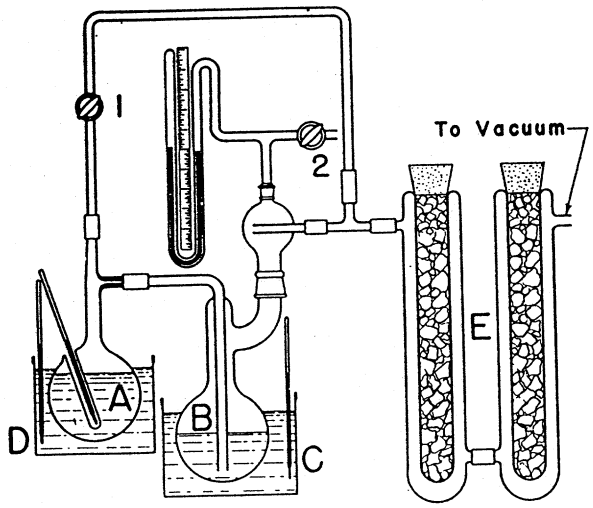

FIG. 1. Laboratory deodorization apparatus.

[1] One of the laboratories of the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, United States Department of Agriculture.

were quickly heated to the desired temperature and maintained at that temperature by means of an oil bath (C). A temperature of 180°C. for one hour, previously found to be satisfactory for producing odorless lard, was used in all the deodorization experiments. Longer periods of heating or higher temperatures, such as 220° to 250°C., often resulted in undesirable color and decreased stability of the product. In view of the low pressures and short period of heating used in these experiments, under the conditions of plant operation similar results would probably be obtained by a continuous process rather than a batch process.

TABLE I

Effects of Deodorization and the Addition of Tocopherol and Synergists on the Stability of Lards A, B, and C

Treatment	Stability (Active Oxygen Method) Hours at 99°C.		
	Steam-rendered lard-A	Steam-rendered lard-B	Kettle-rendered lard-C
Control	10	1	7
Deod[1]	10	1.5	12
+ .06% d-IP[2]	10	1	....
+ .06% lec[3]	14	3.5	....
+ .06% lec, deod	13	9	15
+ .01% toc[4]	26	10	....
+ .01% toc, deod	22	7	42
+ .01% toc + .06% lec	35	24	....
+ .01% toc + .06% lec, deod	35	30	46
+ .01% toc + .06% lec + .06% d-IP[5]	129	42	105
+ .01% toc + .06% lec + .06% d-IP, deod[5]	105	74	80
Deod + .01% toc + .06% lec + .06% d-IP[5]	131	106	122

[1]Deod = deodorized.
[2]d-IP = d-isoascorbyl palmitate (20).
[3] lec = lecithin. Commercial soybean lecithin was used.
[4]toc = tocopherol. Enough of 30% concentrate to furnish 0.01% tocopherol was added.
[5]These lards darkened extensively when heated above 100°C.

The steam pot was heated to 35°C. and maintained at that temperature by the heated water bath (D). At the end of the run, the bath was removed and the flask cooled almost to room temperature before the vacuum was released. Solid carbon dioxide served as the cooling medium in the cold traps (E). With the steam generator at 35°C. and with a pressure of 2.0 to 2.5 mm., approximately 30 grams of water, as steam, was discharged through 100 grams of lard in a 1-hour run. In using this apparatus, it was not necessary to superheat the water vapor.

In some experiments, pure alpha-tocopherol was used; in others a concentrate of tocopherol or corn oil was added to the lard in amounts calculated to furnish 0.01 per cent tocopherol. The Parker-McFarlane modification (17) of the Emmerie-Engel method was used to determine the tocopherol content of the corn oil. The tocopherol, lecithin, and d-isoascorbyl palmitate were incorporated in the lard by direct addition, with gentle warming and with stirring. All the other antioxidants and synergists were added in alcoholic solution, the alcohol being subsequently removed in the deodorizer by heating at 60°C. for 10 minutes under vacuum.

The stability values were determined by the active oxygen method as described previously (18); the oxygen-absorption values were determined by the Barcroft-Warburg technique (19), except that the flasks and manometers were not shaken during the test. The absorption of 300 cu. mm. of oxygen by 0.5 cc. of sample was taken as the end of the induction period.

Results and Discussion

THE effects of deodorization and the addition of tocopherol, lecithin, and d-isoascorbyl palmitate are shown in Table I.

Deodorization had no appreciable effect on the stability of the steam rendered lard but significantly increased the stability of kettle-rendered lard. Deodorization of different samples of kettle-rendered lard, not included in the table, produced similar increases in stability. When deodorization was carried out with lecithin and tocopherol present in steam-rendered lard of low initial stability, the stability was definitely increased. The greatest increase was obtained by adding the tocopherol, lecithin, and d-isoascorbyl palmitate to the deodorized lard. However, when lard containing the ester and lecithin in these concentrations (0.06 percent) was heated, it darkened to an extent that required treatment with decolorizing agents. The color could be removed with carbon and bleaching earths, but this treatment resulted in a loss of 50 to 60 percent of the effect of the antioxidants.

TABLE II

Effects of Deodorization and the Addition of Tocopherol and Synergists on the Stability of Lards D and E

Treatment	Stability (Active Oxygen Method) Hours at 99°C.	
	Steam-rendered lard-D	Steam-rendered lard-E
Control	3	6
Deod[1]	3	7
+ .01% toc[2]	11	18
+ .01% toc, deod	9	....
Deod + .01% toc	....	9
+ .01% toc + .02% d-IP[3] + .01% lec[4]	19	40
Deod + .01% toc + .02% d-IP + .01% lec	36	51
+ .01% toc + .02% d-IP + .01% lec, deod	....	44
+ .01% toc + .02% citric acid + .01% lec	15	24
Deod + .01% toc + .02% citric acid + .01% lec	26	28

[1] Deod = deodorized.
[2] toc = tocopherol. Added as corn oil to furnish 0.01% tocopherol.
[3]d-IP = d-isoascorbyl palmitate (20).
[4]lec = lecithin. Commercial soybean lecithin was used.

The results of another series of experiments in which the concentration of d-isoascorbyl palmitate was reduced to 0.02 percent and the lecithin to 0.01 percent are summarized in Table II, along with the results obtained when the ester was replaced with citric acid. In these experiments also, the greatest stability was obtained when the antioxidants were added to deodorized lard. The color of the lards containing these concentrations of antioxidants was satisfactory, although slight darkening could be detected after deodorization.

Experiments summarized in Table III showed that when nordihydroguaiaretic acid was added to deodorized lard less increase in stability resulted than when it was added to the untreated lard. This may indicate that certain natural synergists had been removed or destroyed by deodorization. The result obtained when nordihydroguaiaretic acid and d-isoascorbyl palmitate were added to deodorized lard supports this explanation. The stability in this case was almost the same as that obtained by adding these combinations to the untreated lard. Deodorization after the addition of this antioxidant mixture reduced the stability substantially.

In the previous three tables the effects of antioxidants and of deodorization have been evaluated by

TABLE III

Effects of Deodorization and the Addition of Nordihydroguaiaretic Acid on the Stability of Lards F and G

Treatment	Stability (Active Oxygen Method) Hours at 99°C.	
	Steam-rendered lard-F	Steam-rendered lard-G
Control	2	8
+ .005% NDGA[1]	12	32
+ .01% NDGA	14	56
+ .02% NDGA	18	78
+ .005% NDGA, deod[2]	11	29
Deod + .005% NDGA	4	15
+ .005% NDGA + .005% d-IP[3]	43	65
Deod + .005% NDGA + .005% d-IP	41	64
+ .005% NDGA + .005% d-IP, deod	22	38
+ .005% NDGA + .005% citric acid	48	57
+ .005% NDGA + .02% citric acid	43	58
+ .01% NDGA + .005% citric acid	....	65
+ .01% NDGA + .01% citric acid	....	79

[1]NDGA = nordihydroguaiaretic acid.
[2]Deod = deodorized.
[3]d-IP = d-isoascorbyl palmitate (20).

the use of only the active oxygen method. For comparative purposes and as an aid in evaluating these data Table IV shows results obtained by both the active oxygen method and the oxygen absorption method when using the same antioxidants in similar concentrations. Both the stability and the protection factors determined by the latter method are consistently lower. Although some general correlation is evident, from the limited number of results shown it appears unlikely that the stability values of fats containing various antioxidants obtained by one method could generally be converted into values obtainable by the other.

Summary

DEODORIZATION produced no appreciable increase in the stability of steam-rendered lard but significantly increased the stability of kettle-rendered lard. A substantial increase in the stability of lard was produced by tocopherol, regardless of whether it was added as a pure compound, as a concentrate, or as a tocopherol-bearing oil. Accelerated tests showed that this increase was more than doubled when small amounts of synergists also were added. Deodorization of the lard prior to addition of the synergistic antioxidant compositions produced even greater stability.

Nordihydroguaiaretic acid was more effective than tocopherol as an antioxidant for lard, as determined by both the active oxygen and the oxygen-absorption methods. Deodorization of the lard prior to addition of this antioxidant and synergists did not effect further increase in stability over that obtained by the addition of these materials to undeodorized lard.

TABLE IV

Stability Values of Lard Containing Antioxidants as Determined by the Active Oxygen and by the Oxygen-Absorption Methods

Treatment	Stability			
	Active Oxygen Method		Oxygen-Absorption Method (Barcroft-Warburg)	
	Hrs. at 99°	P.F.[1]	Hrs. at 100°	P.F.
Control	6	....	2.8	....
+ .01% toc[2]	26	4.3	3.4	1.2
+ .01% toc + .02% d-IP[3] + .01% lec	40	6.7	14.4	5.2
+ .005% NDGA[4]	27	4.5	8.3	3.0
+ .005% NDGA + .005% d-IP	67	11.2	26.2	9.4
+ .005% NDGA + .005% citric acid	53	8.8	23.7	8.5
+ .005% NDGA + .005% ascorbic acid	78	13.0	22.0	7.9
+ .005% NDGA + .005% tartaric acid	57	9.5	17.0	6.1
+ .005% NDGA + .005% aconitic acid	33	5.5	14.5	5.2

[1]P.F. = $\frac{\text{Stability of treated sample}}{\text{Stability of control.}}$
[2]toc = alpha-tocopherol.
[3]d-IP=d-isoascorbyl palmitate (20).
[4]NDGA=nordihydroguaiaretic acid.

In most instances, deodorization after the addition of synergistic compositions resulted in some decreases in stability, as compared with similar additions to the lard without deodorization.

REFERENCES CITED

(1) Newton, R. C., and Grettie, D. P., U.S. Patent 1,903,126 (1933).
(2) Grettie, D. P., Oil and Soap *10*, 126 (1933).
(3) Olcott, H. S., and Mattill, H. A., J. Am. Chem. Soc., *58*, 1627 (1936).
(4) Olcott, H. S., and Emerson, O. H., J. Am. Chem. Soc., *59*, 1008 (1937).
(5) Olcott, H. S., Oil and Soap, *18*, 77 (1941).
(6) Golumbic, C., and Mattill, H. A., J. Biol. Chem., *134*, 535 (1940).
(7) Golumbic, C., and Mattill, H. A., J. Am. Chem. Soc. *63*, 1142 (1941).
(8) Riemenschneider, R. W., Turer, J., Wells, P. A., and Ault, W. C., Oil and Soap, *21*, 47 (1944).
(9) Lundberg, W. O., Halvorson, H. O., and Burr, G. O., Oil and Soap, *21*, 33 (1944).
(10) United States Department of Agriculture, Bureau of Animal Industry Circular Letter No. 2354, December 26, 1941.
(11) Private communication stating that individual requests for permission to add lecithin to lard or "rendered pork fat" have been granted.
(12) War Food Administration Meat Inspection Division Memorandum No. 25, Dec. 11, 1943.
(13) War Food Administration Meat Inspection Division Memorandum No. 29, Feb. 10, 1944.
(14) Lee, A. P., and King, W. G., Jr., Oil and Soap, *14*, 263 (1937).
(15) Bailey, A. E., Ind. Eng. Chem., *33*, 404 (1941).
(16) Bailey, A. E., and Feuge, R. O., Ind. Eng. Chem., Anal. Ed., *15*, 280 (1943).
(17) Parker, W. E., and McFarlane, W. D., Can. J. Res., *18B*, 405 (1940).
(18) Riemenschneider, R. W., Turer, J., and Speck, R. M., Oil and Soap, *20*, 169 (1943).
(19) Johnston, W. R., and Frey, C. N., Ind. Eng. Chem., Anal. Ed., *13*, 479 (1941).
(20) Swern, D., Stirton, A. J., Turer, J., and Wells, P. A., Oil and Soap *20*, 224 (1943).